AMENDMENTS TO THE CLAIMS:

1. (Currently amended) A semiconductor device to be mounted onto a circuit board, comprising:

a semiconductor element having a thickness of at most 100μm, said semiconductor element having a first surface bearing a terminal ~~formed thereon~~ for external connection, and a second surface opposite said first surface;

a plate confronting said second surface; and

a bonding layer ~~for bonding~~ between said second surface and said plate such that said semiconductor element is bonded to said plate via said bonding layer, said bonding layer having a thickness within a range of from 25μm to 200μm and having a modulus of elasticity to allow for deformation of said semiconductor element;

~~wherein said bonding layer has a thickness of 25μm or greater but 200μm or smaller~~.

2. (Currently amended) The semiconductor device ~~of~~ according to claim 1, wherein said ~~bonding layer has a~~ modulus of elasticity ~~of~~ is at most 10,000Mpa ~~or less~~.

3. (Currently amended) The semiconductor device ~~of~~ according to claim 1, wherein said bonding layer contains filler having a diameter generally equal to the thickness of said bonding layer.

4. (Currently amended) The semiconductor device ~~of~~ according to claim 3, wherein said filler is in contact with said second surface of said semiconductor element and said plate.

5. (Currently amended) The semiconductor device ~~of~~ according to claim 1, wherein said filler includes any of inorganic material and polymeric material.

6. (Currently amended) The semiconductor device ~~of~~ according to claim 1, wherein said bonding layer contains filler having at least two ~~or more~~ different particle sizes, ~~and~~ with at least one of said particle sizes ~~in said filler~~ being ~~is~~ generally equal in dimension to the thickness of said bonding layer.

7. (Currently amended) The semiconductor device ~~of~~ according to claim 1, wherein: said bonding layer contains first filler and second filler~~;~~ ,

with said first filler ~~has~~ having a size generally equal to the thickness of said bonding ~~layer;~~ layer, and said second filler ~~has~~ having a particle size distribution in sizes smaller than the size of said first filler.

Claim 8 (Cancelled)

9. (Currently amended) The semiconductor device ~~of~~ according to claim 1, wherein: ~~a thickness of said semiconductor element is 100im or smaller;~~

~~a~~ said modulus of elasticity ~~of said bonding layer~~ is at most 10,000Mpa, and ~~or less;~~

said bonding layer contains first filler and second filler, ~~and~~ with said first filler ~~has~~ having a particle size generally equal to the thickness of said bonding ~~layer;~~ layer, and said second filler ~~has~~ having a particle size distribution in sizes smaller than the size of said first filler.

10. (Currently amended) The semiconductor device ~~of~~ according to claim 9, wherein said first filler maintains a space between said second surface and said plate.

11. (Currently amended) The semiconductor device ~~of~~ according to claim 1, wherein ~~further comprising a bump formed on~~ said terminal for external connection comprises a bump.

12. (Currently amended) The semiconductor device ~~of~~ according to claim 1, wherein:

said first surface has ~~semiconductor element is provided with~~ a re-wiring layer ~~on said first surface;~~ thereon, with said re-wiring layer ~~has~~ having a surface electrode formed on a surface thereof and an internal electrode formed inside thereof, ~~; and~~

with said internal electrode ~~is~~ being in communication ~~between~~ with said surface electrode and said terminal for external connection.

13. (Currently amended) The semiconductor device ~~of~~ according to claim 12, further comprising a bump ~~formed~~ on said surface electrode.

Claim 14 (Cancelled)

15. (Currently amended) The resin binder ~~of~~ according to claim ~~14~~ 26, wherein a percentage of content of said ~~fillers~~ filler in said resin binder is at most 30 percent ~~percents or less~~ by weight.

16. (Currently amended) The resin binder ~~of~~ according to claim ~~14~~ 26, wherein said ~~largest~~ filler comprises any of inorganic material and polymeric material.

17. (Currently amended) The resin binder ~~of~~ according to claim ~~14~~ 26, wherein said ~~bonding layer formed of said resin binder has a~~ modulus of elasticity ~~of~~ is at most 10,000Mpa ~~or less~~.

18. (Currently amended) The resin binder ~~of~~ according to claim ~~14~~ 26, wherein: said ~~fillers~~ comprises a first filler and a second filler~~;~~ ,

with said first filler ~~has~~ having ~~a~~ the particle size generally equal to the thickness of said bonding ~~layer;~~ layer, and said second filler ~~has~~ having a particle size distribution in sizes smaller than the particle size of said first filler.

19. (Currently amended) The resin binder ~~of~~ according to claim 18, wherein an ~~aggregated~~ aggregate percentage of content of said first filler and said second filler in said resin binder is at most 30 percent ~~percents or less~~ by weight.

20. (Currently amended) The resin binder ~~of~~ according to claim 18, wherein at least said first filler comprises resin.

21. (Currently amended) The resin binder ~~of~~ according to claim 18, wherein at least said first filler comprises inorganic material.

22. (Currently amended) The resin binder ~~of~~ according to claim 18, wherein said ~~bonding layer formed of said resin binder has a~~ modulus of elasticity ~~of~~ is at most 10,000Mpa ~~or less~~.

23. (New) The semiconductor device according to claim 7, wherein an aggregate percentage of content of said first filler in said bonding layer is at most 30 percent by weight.

24. (New) The semiconductor device according to claim 7, wherein an aggregate percentage of content of said first filler and said second filler in said bonding layer is at most 30 percent by weight.

25. (New) The semiconductor device according to claim 1, wherein said plate has an external shape larger than an external shape of said semiconductor element, and said bonding layer covers a side edge of said semiconductor element.

26. (New) A resin binder for use in a semiconductor device that includes a semiconductor element bonded to a reinforcing plate via a bonding layer having a predetermined thickness, wherein the semiconductor element has a thickness of at most 100μm and a terminal thereon for external connection, and wherein the bonding layer comprises said resin binder,

said resin binder containing a filler having a particle size being generally equal in dimension to the predetermined thickness of the bonding layer, and

said resin binder being of a composition such that the bonding layer has a modulus of elasticity to allow for deformation of the semiconductor element when bonded to the reinforcing plate.

REMARKS

In view of the above amendments and following remarks, reconsideration and further examination are requested.

The specification and abstract have been reviewed and revised to make editorial changes thereto and generally improve the form thereof, and a substitute specification and abstract are provided. No new matter has been added by the substitute specification and abstract.

By the current Amendment, claims 1-7, 9-13 and 15-22 have been amended, claims 8 and 14 have been canceled, and claims 23-26 have been added.

The instant invention pertains to a semiconductor device that is to be mounted to a circuit board. Generally speaking, when a semiconductor element is mounted onto a circuit board by performing a flip chip mounting operation, a problem of reliability of the semiconductor element arises due to a difference in coefficients of thermal expansion of the semiconductor element and the circuit board. For example, if the semiconductor element, while mounted on the circuit board, undergoes a heat cycle test, a bonding member, e.g. solder, bonding the semiconductor element to the circuit board cracks and thereby results in a disconnection of the semiconductor element from the circuit board.

When the semiconductor element is an extremely thin element, as with the instant invention, having a thickness of at most 100μm, attaching a plate to a back surface of the semiconductor element is necessary to ensure a reliable connection between the semiconductor element and a circuit board. Additionally, by attaching such a thin semiconductor element to the plate, the semiconductor element can be easily handled during a mounting procedure. However, in order to ensure reliability of the semiconductor element when mounted on the circuit board, it is important that the semiconductor element be attached to the reinforcing plate in a unique and optimal manner as discovered by Applicants.

In this regard, Applicants have discovered that a specific thickness and modulus of elasticity of a bonding layer, joining such a thin semiconductor element to the plate, is necessary to ensure that the semiconductor element is attached to the circuit board in a reliable manner. Specifically, Applicants have discovered that a bonding layer having a thickness within a range from 25μm to 200μm, and having a modulus of elasticity that allows the semiconductor element to deform while

bonded to the plate, enables a long-lasting connection of the semiconductor element to the circuit board.

Accordingly, in accordance with a first aspect of the invention, the semiconductor device comprises a specific bonding layer provided between a back side of a semiconductor element, having a thickness of at most 100μm, and a plate such that the plate is bonded to the semiconductor element via the bonding layer. The bonding layer has a modulus of elasticity to allow for deformation of such an extremely thin semiconductor element, and also has a thickness within a range of from 25μm to 200μm. Amended claim 1 is believed to more clearly bring out these inventive features of the bonding layer.

Additionally, in order to ensure that the thickness of the bonding layer is within the optimal range of from 25μm to 200μm, the bonding layer includes a filler having a particle size that is generally the same as the thickness of the bonding layer. Accordingly, in accordance with a second aspect of the invention, provided in the bonding layer is a filler having a particle size that is generally the same as the thickness of the bonding layer. New claim 26 is believed to more clearly bring out this feature of the invention.

In section 2 on pages 2-3 of the Office Action, the Examiner has rejected claims 1, 5 and 11 under 35 U.S.C. § 102(b) as being anticipated by Tobita et al. In section 4 on pages 3-4 of the Office Action, the Examiner has rejected claim 2 under 35 U.S.C. § 103(a) as being unpatentable over Tobita et al. in view of Takano et al. In section 5 on pages 4-6 of the Office Action, the Examiner has rejected claims 3, 4, 6, 7, 14, 16, 18, 20 and 21 under 35 U.S.C. § 103(a) as being unpatentable over Tobita et al. in view of Distefano et al. In section 6 on pages 6-7 of the Office Action, the Examiner has rejected claims 12 and 13 under 35 U.S.C. § 103(a) as being unpatentable over Tobita et al. in view of Inaba et al. In section 7 on page 8 of the Office Action, the Examiner has rejected claim 8 under 35 U.S.C. § 103(a) as being unpatentable over Tobita et al. and Distefano et al., and further in view of Barton. In section 8 on pages 8-9 of the Office Action, the Examiner has rejected claims 9 and 10 under 35 U.S.C. § 103(a) as being unpatentable over Tobita et al. in view of Distefano et al., Barton and Takano et al. In section 9 on pages 9-10 of the Office Action, the Examiner has rejected claims 15 and 19 under 35 U.S.C. § 103(a) as being unpatentable over Tobita et al. and Distefano et al., and further in view of Shikata et al. And, in section 10 on page 10 of the

Office Action, the Examiner has rejected claims 17 and 22 under 35 U.S.C. § 103(a) as being unpatentable over Tobita et al. and Distefano et al., and further in view of Takano et al.

These rejections are respectfully traversed and the references relied upon by the Examiner are not applicable with regard to the currently amended and new claims for the following reasons.

In rejecting claim 1 as being anticipated by Tobita et al., the Examiner took the position that semiconductor element 12 corresponds to the claimed "semiconductor element", spreader 19 corresponds to the claimed "plate", and grease 18 corresponds to the claimed "bonding layer".

As alluded to above, claim 1 has been amended to more clearly recite the inventive features of the invention. In this regard, claim 1 now recites

> A semiconductor device **to be mounted onto a circuit board**, comprising:
>
> **a semiconductor element having a thickness of at most 100μm**, said semiconductor element having a first surface bearing a terminal for external connection, and a second surface opposite said first surface;
>
> a plate confronting said second surface; and
>
> a bonding layer between said second surface and said plate such that said semiconductor element is bonded to said plate via said bonding layer, **said bonding layer having a thickness within a range of from 25μm to 200μm and having a modulus of elasticity to allow for deformation of said semiconductor element**. (Emphasis added)

With regard to Tobita et al., though Figure 2 appears to show a semiconductor element 12 bonded to a plate 19 via a bonding layer 18, it is unclear at to whether the semiconductor element 12 is bonded to the plate 19 prior to the semiconductor element 12 being connected to printed circuit board 11, or whether the semiconductor element 12 is first connected to the circuit board 11 and then bonded to the plate 19.

According to the instant invention as recited in claim 1, the semiconductor device is "to be mounted onto a circuit board". In other words, claim 1 is believed to make it clear that the semiconductor element is bonded to the plate via the bonding layer prior to the semiconductor element being connected to any circuit board. This is significant because one of the advantages of bonding a thin semiconductor element to a plate, in accordance with the instant invention, is that the

semiconductor element can be easily handled. Accordingly, because Tobita et al. does not make it clear that semiconductor element 12 is connected to plate 19 via grease 18 prior to semiconductor element 12 being connected to the circuit board 11, it is respectfully submitted that for this reason alone claim 1 is not anticipated by Tobita et al.

In order to lend more patentable significance to the thickness and modulus of elasticity of the bonding layer, claim 1 also now recites that the thickness of the semiconductor element is at most 100μm. As explained previously, it is use of such a thin semiconductor element that resulted in Applicants' discovery of the thickness and modulus of elasticity as recited in claim 1.

The thickness of the semiconductor element was originally recited in dependent claim 8. The Examiner recognized that Tobita et al. does not disclose that the thickness of semiconductor element 12 is at most 100μm, and thus relied upon a combination of Tobita et al. and Barton to render claim 8 obvious.

With regard to Barton, even though this reference discloses an element 12 having a thickness of about 1-20 mils, this element is but a single element of a hybrid infrared detector 10. In this regard, element 12 is silicon read-out circuit that is sandwiched between a read-out substrate 11 and an active layer on a transparent substrate 14. Read-out circuit 12 and read-out substrate 11 are bonded to each other via an adhesive such as an epoxy glue 21. Thus, the read-out circuit 12 is but a sub-component of hybrid infrared detector 10. To the contrary, semiconductor element 12 of Tobita et al. appears to be in and of itself a component. Accordingly, it is not seen how the thickness of a sub-component, forming part of an infrared detector, would have led one having ordinary skill in the art to have modified a component, mounted to a circuit board, such that this component is the same thickness as the sub-component. Thus, for this reason claim 1 is not obvious over a combination of Tobita et al. and Barton, even if all of the other features of claim 1 were somehow taught or rendered obvious by Tobita et al. or Barton.

Furthermore, even though Tobita et al. does appear to disclose the claimed thickness of the bonding layer in paragraph 58, this thickness is chosen with regard to ease of manufacture and maintaining a low thermal resistance, whereas with regard to the instant invention the thickness of the bonding layer is chosen so as to ensure prevention of disconnection between a circuit board and the semiconductor element. Additionally, the modulus of elasticity of grease 18 is not disclosed or

suggested to be such as to allow for deformation of the semiconductor element 12 as required by claim 1.

None of the other references resolve these deficiencies of Tobita et al. and Barton, and accordingly, claim 1 is allowable over any possible combination of the references relied upon.

With regard to claim 26, this claim is similar to claim 1 in that it recites a resin binder for use as a bonding layer in a semiconductor device that has a semiconductor element, having a thickness of at most 100μm, bonded to a plate via the bonding layer, wherein the bonding layer has a modulus of elasticity to allow for deformation of the semiconductor element when bonded to the plate.

Claim 26 additionally requires that the resin binder contains a filler having a particles size that is generally equal in dimension to the thickness of the bonding layer. The significance of having the filler be of such a dimension is that it functions as a spacer between the plate and the semiconductor element and regulates a thickness of the bonding layer.

With regard to the claims requiring that the thickness of the filler is equal to the thickness of the bonding layer, the Examiner relied upon Distefano et al. for a finding that these claims would have been obvious as expressed in the paragraph bridging the pages 5 and 6 of the Office Action. However, Distefano et al. does not disclose a filler that is used as a spacer to control the thickness of a bonding layer as with the instant invention.

In this regard, the purpose of the filler particles in Distefano et al. are for increasing tensile strength and solvent resistance, and improving thermal conductivity, and are not disclosed to be used as a spacer. With regard to the position taken by the Examiner in the paragraph bridging pages 5 and 6 of the Office Action, while it is true that if a filler having a particle size of 50μm were incorporated into a resin sheet of the type disclosed by Tobita et al. having a thickness of 50μm, and were this resin sheet positioned between two members, the filler would probably contact surfaces of these two members; however, it is respectfully submitted that there would have been no motivation or suggestion to have modified Tobita et al. by including in the bonding material thereof the fillers of Distefano et al.

In this regard, there is nothing in either Tobita et al. or Distefano et al. that would suggest that the fillers of Distefano et al. might somehow be utilized for a beneficial purpose in the bonding

material of Tobita et al. This is especially true in light of the different materials employed by Distefano et al. and Tobita et al.

Furthermore, because the fillers of Distefano et al. are not disclosed to be used as a spacer, Distefano et al. can be said to teach that the fillers are to be of such a particle size so as to be dispersed throughout the encapsulate thereof and of a particle size smaller than a thickness of the encapsulate. Accordingly, if the fillers of Distefano et al. were somehow found to be beneficial in the bonding material of Tobita et al., then it is reasonable to expect that the filler particles would be of a size so as to be easily dispersed in the bonding material and smaller than the thickness of the bonding layer of Tobita et al.

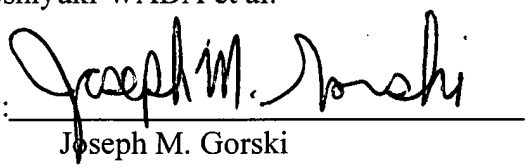
For the above reasons, it is respectfully submitted that claim 26 is not obvious over a combination of Tobita et al. and Distefano et al. None of the other references resolve these deficiencies of Tobita et al. and Distefano et al., and accordingly, claim 26 is allowable over any possible combination of the references relied upon.

In view of the above amendments and remarks, it is respectfully submitted that the present application is in condition for allowance and an early Notice of Allowance is earnestly solicited.

If after reviewing this Amendment, the Examiner believes that any issues remain which must be resolved before the application can be passed to issue, the Examiner is invited to contact the Applicants' undersigned representative by telephone to resolve such issues.

Respectfully submitted,

Yoshiyuki WADA et al.

By: 

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December 14, 2004